THE ANATOMY OF THE INFERIOR ETHMOIDAL TURBINATE BONE WITH PARTICULAR REFERENCE TO CELL FORMATION; SURGICAL IMPORTANCE OF SUCH ETHMOID CELLS.

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Method of Investigation.—The results presented below are based upon a study of about 1000 specimens obtained in the dissecting-room and the Warren Museum of the Harvard Medical School. Most of the specimens represent dissecting-room material intact and in a good state of preservation, and the balance consists of about seventy skulls in which the bony outer wall of the nasal fossa was not broken. Some of the specimens were studied before and after maceration. In no instance was the clinical nasal history known. I am indebted to Professor Thomas Dwight for the opportunity to carry on this investigation. I owe much to Percy Emerson Brown, M.D., for his skill in obtaining photographs of the specimens.

Nasal Fossa.—The nasal fossæ are two more or less symmetrical cavities placed side by side and separated from each other by the septum of the nose which forms the internal wall in either instance (Figs. 9, 11, and 13). The fossa is open in front and behind at the anterior and posterior nares and is bounded above and below and laterally by four walls. The floor is much wider than the roof and the lateral walls are the most extensive. The nasal fossæ are surrounded by four other fossæ,—above is the cranial fossa; laterally, the orbital fossæ; and below, the cavity of the mouth.

The floor of the nasal fossæ will not be considered. Certain features of the roof and internal wall which bear important relations to the inferior ethmoidal turbinate will be referred to. The outer wall is not only the most intricate, but also is of

the greatest surgical importance. This outer wall is bounded chiefly by the internal surface of the body of the superior maxilla and its nasal process, and by the internal surface of the lateral mass of the ethmoid bone, but, in addition, this wall is completed by the nasal, lachrymal, and inferior turbinate bones, and internal pterygoid plate of the sphenoid bone (Fig. 1). The most striking feature of this wall is its irregularity made by two large bony projections called the inferior turbinate bone and the inferior ethmoidal turbinate ("middle turbinate"). There are always one or more lesser projections which are called superior turbinate bodies, but these are of little clinical importance.

The ethmoid bone is usually described as presenting a median vertical plate (lamina perpendicularis) which forms part of the nasal septum, and across the top of this is a horizontal, perforated plate (lamina cribrosa) which separates the nasal and cranial fossæ. On either side of the lamina perpendicularis, suspended from the lamina cribrosa, is a cuboidal, cellular mass of bone called the "lateral mass." The outer wall of the lateral mass is bounded by a flat plate of bone, called the os planum, forming part of the inner wall of the orbit. The inner wall of this lateral mass is very irregular and forms a part of the outer wall of the nasal fossa. The irregular bony cells between these two walls constitute the greater portion of the anterior and posterior ethmoidal cells (Figs. 9, 11, and 13). All the ethmoidal turbinate bodies or bones are projections from this internal wall (Fig. 1). The lower projection is called the inferior ethmoidal turbinate ("middle turbinate"), and is the structure under particular consideration in the following pages.

Internal Wall of the Lateral Mass (Figs. 1–6, 15, and 16).—The internal wall of the lateral mass is a more or less quadrangular area of bone, which serves both as an internal boundary for many of the ethmoid cells and likewise as a portion of the external wall of the nasal fossa. It consists entirely of a portion of the ethmoid bone. The upper border corresponds to the line of junction of this surface and the lamina

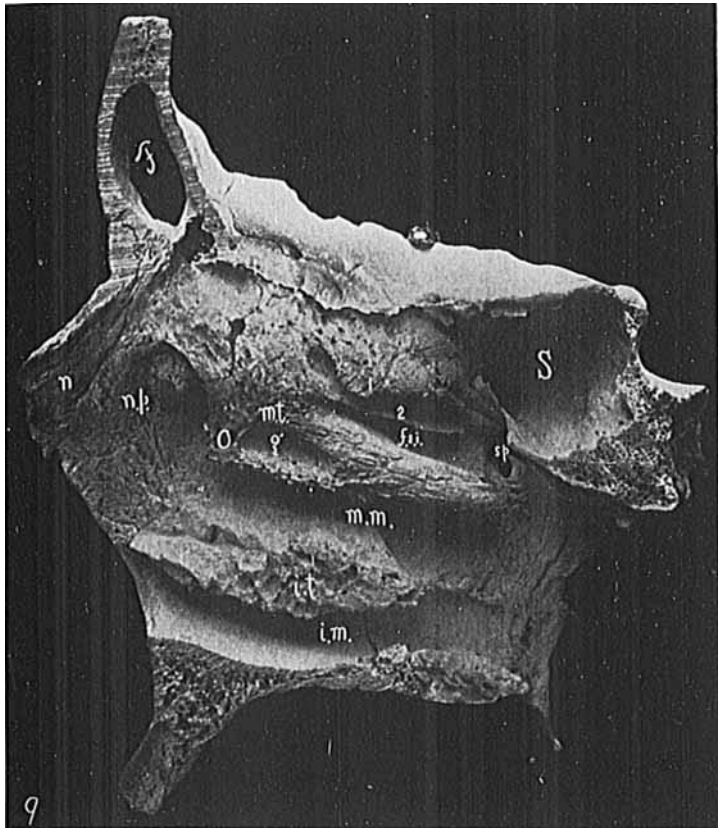


FIG. 1.—Outer bony wall of right nasal fossa; dotted line marks its roof. *F*, frontal sinus; *S*, sphenoidal sinus; *n*, nasal bone; *n.p.*, nasal process of superior maxilla; *s.p.*, sphenopalatine foramen; *m.t.*, middle turbinate; *O*, operculum; *g*, deep groove in middle turbinate; *f.e.i.*, fissura ethmoidalis inferior; 1 and 2, two superior turbinate bones with a deep middle ethmoidal fissure between them; *m.m.*, middle meatus; *i.t.*, inferior turbinate; *i.m.*, inferior meatus.

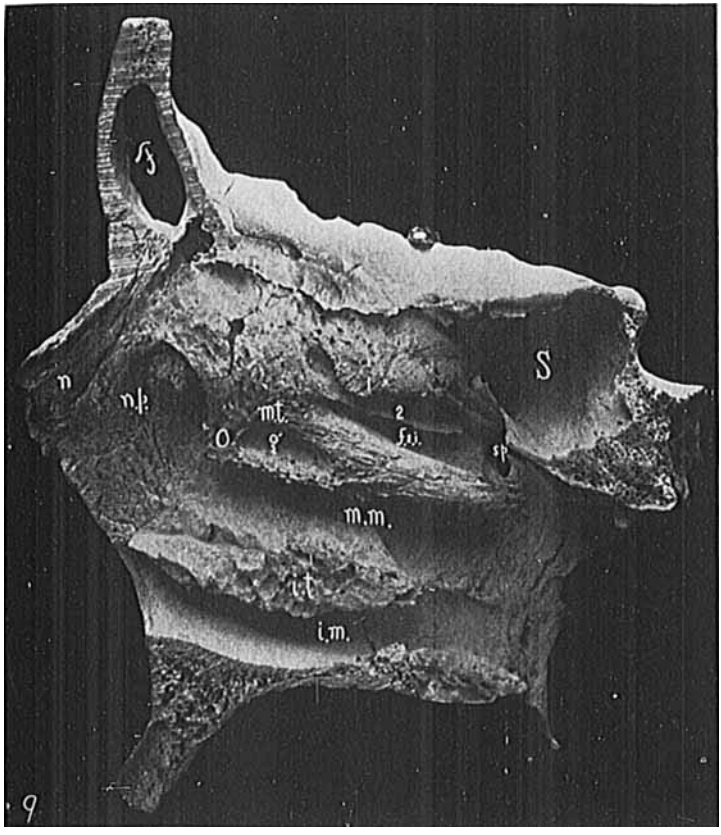


FIG. 2.—Outer wall of right nasal fossa; dotted line marks its roof. *F, F,* frontal sinus; *c.g.,* crista galli, which is hollow and communicates with the frontal sinus; *p,* posterior ethmoid cell. Arrow passes from a sphenoidal sinus through its ostium sphenoidale. *m.t.,* middle turbinate relatively very large. Mucous membrane hypertrophied. Inferior border, fifty millimetres; anterior border, thirty-three millimetres; height of nasal fossa, forty-six millimetres. *O,* operculum prominent; 1 and 2, two superior turbinate bones with a middle ethmoidal fissure between; *f.e.t.,* inferior ethmoidal fissure; *a.o.m.,* accessory ostium maxillare; *i.t.,* inferior turbinate.

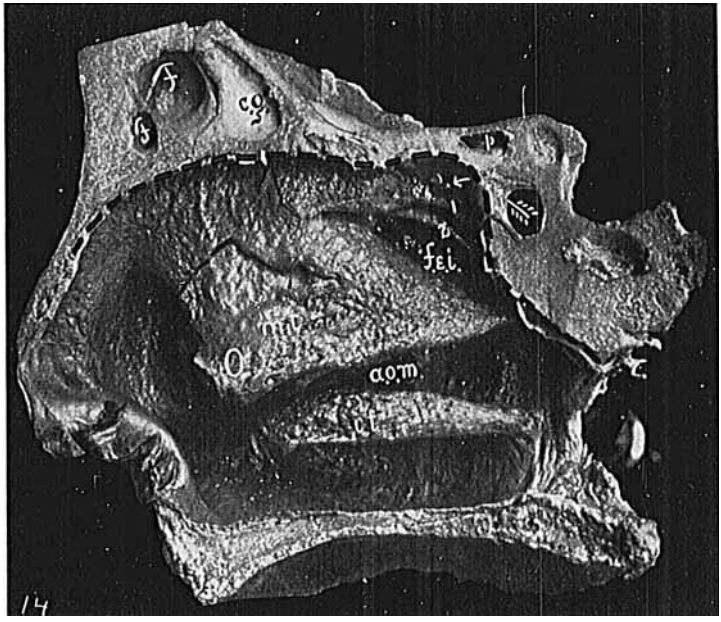


FIG. 3.—Outer wall of right nasal fossa showing an extreme degree of atrophy; dotted line marks roof of fossa. *S*, sphenoidal sinus, small and subdivided by cellular partitions. Arrow enters sinus through the ostium sphenoidale; *s.t.*, much atrophied superior turbinate; *f.e.i.*, fissura ethmoidalis inferior; *m.t.*, extreme atrophy of middle turbinate which consists chiefly of a fold of membrane without bone tissue; *B*, ethmoid bulla, above which is its ostium; anteriorly is an arrow leading to the frontal sinus; *U*, uncinate process, behind which an arrow passes through the ostium maxillare to a very small antrum; *i.t.*, inferior turbinate.

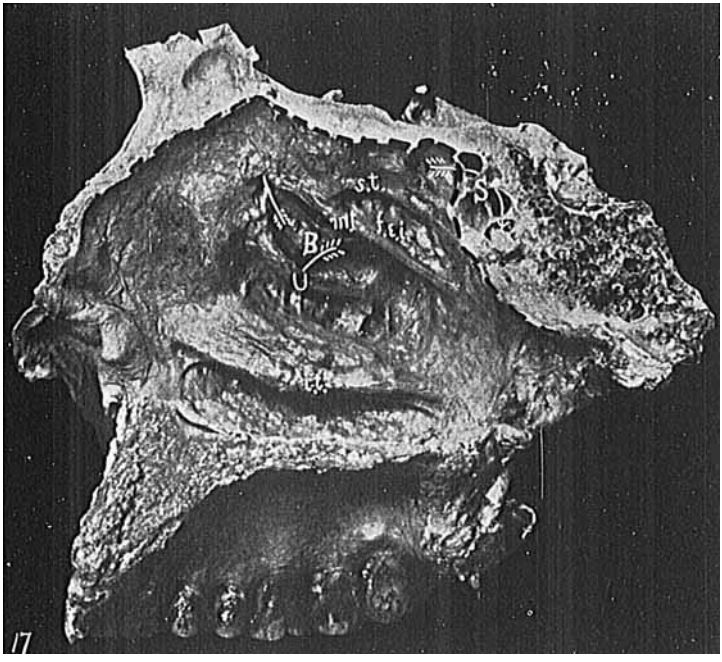


FIG. 4.—Outer wall of left nasal fossa; dotted line marks its roof. *F*, frontal sinus; *S*, sphenoidal sinus, arrow passes through its ostium; *s.e.*, spheno-ethmoidal recess; *s.t.*, superior turbinate; *f.e.t.*, inferior ethmoidal fissure prolonged as a groove (*g*) on the middle turbinate (*m.t.*); *m.m.*, middle meatus, with arrow passing into a large cell in the middle turbinate bone (c). The inner wall of this cell has been removed, exposing a swelling (*a*) which passes into this cell. This swelling is an unusually formed anterior ethmoid cell, into which an arrow is made to pass; it is fifteen millimetres long. The middle turbinate cell measures fifteen millimetres long, twenty-five millimetres high, and twelve millimetres wide. Inferior border of turbinate measures fifty-five millimetres, and the anterior border, thirty millimetres. *i.t.*, inferior turbinate; *i.m.*, inferior meatus.

cribrosa and is carried forward anteriorly on to the inner surface of the nasal process of the superior maxilla, and posteriorly to the ethmoid spine of the sphenoid bone. It is slightly convex towards the septum corresponding to the narrow portion of the roof of the nasal fossa (one to five millimetres). The inferior border is free and corresponds to the inferior border of the inferior ethmoidal turbinate (to be described later) and the anterior border of this surface corresponds to the anterior border of this turbinate. The posterior border is vertical and is the line of junction between this surface and the anterior surface of the body of the sphenoid bone. It forms a vertical groove and is called the spheno-ethmoidal recess.

The surface, as a whole, is rough, and its most striking feature is the presence of an oblique deep groove which, if continued, divides it into two triangles. The groove is known as the inferior ethmoidal fissure (all lateral views). The lower triangle is the inferior ethmoidal turbinate ("middle turbinate" of the nose). The upper triangle may present an intact surface, but is frequently subdivided by a fissure known as the superior ethmoidal fissure and rarely by another fissure (fissura suprema) (Fig. 1). According to the presence of these fissures there will be a variation in the number of superior ethmoidal turbinate bodies. This upper triangle forms the proper internal wall of most of the posterior ethmoidal cells. Its surface is somewhat convex towards the nasal septum, and posteriorly it looks backward towards the sphenoid bone. The surface is rough in consequence of numerous small vertical grooves and foramina for branches of the olfactory nerves.

Inferior Ethmoidal Fissure (Lateral views).—The inferior ethmoidal fissure is always present and runs obliquely downward and backward across the posterior half of this surface of the lateral mass. The anterior extremity starts just below the centre of the surface, about fifteen to twenty centimetres from the anterior border, and intersects the posterior border. Below, it forms the posterior part of the upper boundary of the inferior ethmoidal turbinate, and its upper border is made by the free edge of the next ethmoidal turbinate

("superior turbinate"). Its posterior extremity is open and ceases near the sphenopalatine foramen, but it is closed in front. Usually two or three posterior ethmoidal cells open into it by means of ostia which are apt to be larger than ostia of anterior cells. The floor of the fissure is made by the horizontal position of the inferior ethmoidal turbinate (Figs. 10 and 13) and looks upward and backward. It is comparatively broad and may extend to the os planum (Fig. 10). Pus from these cells is usually directed towards the pharynx. The fissure ends abruptly, but in certain cases it is prolonged as a shallow groove for a variable distance on the internal surface of the inferior ethmoidal turbinate (Fig. 4), or may be carried forward into the turbinate body itself and there dilated into a cell, as will be described later (Figs. 5, 15, and 16). The average inferior ethmoidal fissure measures twenty-six millimetres in length and about six millimetres in width.

Superior Ethmoidal Fissure (Figs. 1, 2).—This fissure is absent in at least 60 per cent. of the cases. When present, it has the same general direction as the inferior ethmoidal fissure. It is about half as long and is situated a short distance above it. It is a groove, deeper in the centre, and it terminates posteriorly in the spheno-ethmoidal recess. It is exceptional for it to possess the ostium of more than one posterior ethmoidal cell. In very rare instances there may be still another groove above this known as the "supreme ethmoidal fissure."

When only the inferior fissure is present, there are two ethmoidal turbinate bodies; the presence of the superior fissure adds a third body. Hence, counting the inferior turbinate bone, there are three turbinate bones, so called, in about 60 per cent. of the cases, and the presence of four such bodies is not unusual, but a fifth is very rare. Only the inferior turbinate bone and the inferior ethmoidal turbinate ("middle turbinate") have any real practical importance. The spheno-ethmoidal recess is a vertical groove just in front of the anterior surface of the body of the sphenoid bone where the ethmoidal fissures terminate behind, and into which opens the sphenoidal sinus.

Ethmoid Cells (Figs. 9, 11, 13, and 16).—The ethmoid

cells will be considered only in a general way. They are most conveniently divided into two groups,—the anterior and posterior cells. They are contained in whole or in part in some portion of the lateral mass of the ethmoid bone and completed by portions of facial bones, which need not be considered here. All cells whose ostia open below the inferior ethmoidal turbinate are called anterior cells, those which open above are called posterior cells. In a general way, the anterior cells are in front of the posterior cells, although they may overlap extensively. The division into a middle group situated opposite the os planum does not appeal to the writer.

The anterior cells have been described in a previous work * with considerable detail, and were summarized as follows:

A series of cells whose ostia are situated along two ethmoidal fissures (homologues), viz., along the hiatus semilunaris, and the fissure between the bulla ethmoidalis and the inferior ethmoidal turbinate. There are three groups of cells:

(*a*) A group represented by the bulla ethmoidalis and its subdivisions.

(*b*) A group of cells crowding into the posterior angle of the frontal sinus which drain into the infundibulum, the turbinate fossa, and the upper part of the fissure above the bulla.

(*c*) A group of cells opposite the lachrymal bone which drain into the infundibulum.

The Posterior Ethmoid Cells.—In general, these cells are situated behind the anterior cells. They are bounded internally by the internal wall of the lateral mass (Figs. 9 and 13), in the ethmoidal fissures of which are situated their ostia. Posteriorly these cells are in close contact with the sphenoidal sinus and may run back external to it. The sinus, however, always has its own ostium which opens into the spheno-ethmoidal recess. Externally these cells are limited chiefly by the internal wall of the orbital fossa. Above they enter a

* Lothrop, "Frontal Sinus and Anterior Ethmoid Cells," ANNALS OF SURGERY, 1898.

varying distance between the two laminæ of the horizontal portion of the orbital plate of the frontal bone (Fig. 2). They are larger and less numerous than the anterior cells and usually number from four to seven. There is a cell in front of the sphenoidal sinus, opposite the superior turbinate, which is generally the largest, and it may equal this sinus in size. The ostia of these cells are few. There may be one to three in the inferior ethmoidal fissure, and one in the superior fissure if this fissure happens to be present. These cells almost never open into the spheno-ethmoidal recess. The superior turbinate body may consist simply of a ridge of bone on the wall of a large cell (Fig. 10). There is sometimes a prominence made by this cell called the "tuberculum ethmoidale posticum." A posterior cell may communicate with the cell of the inferior ethmoidal turbinate (Figs. 15 and 16). The total capacity of the posterior cells is usually less than that of the anterior, although, individually, they may be larger. Their ostia are so large and their drainage so good that they are less liable to be the seat of suppurative disease. The ethmoidal cells are absent at birth (Fig. 7), but develop slowly, and are not completely formed before the age of twenty years.

The Inferior Ethmoidal Turbinate (all lateral views).—The inferior ethmoidal turbinate bone is the antero-inferior triangle marked off on the internal wall of the lateral mass of the ethmoid by the inferior ethmoidal fissure and a line projected forward and upward to the anterosuperior angle of the surface. The lower part of the turbinate hangs more or less vertically as a free lamella of bone (Figs. 9 and 11). It is commonly called the "middle turbinate bone," but it is a part of the ethmoid bone, and is more accurately termed the inferior ethmoidal turbinate.

The general shape of this lamella of bone is triangular, and it presents for descriptive purposes two surfaces, internal and external; three borders, superior, anterior, and inferior, and three angles, posterior, superior, and anterior.

Internal Surface.—The bony surface is rough, but when covered with mucous membrane it is comparatively smooth.

It is triangular and narrow posteriorly, and presents a varying degree of convexity towards the septum. The anterior and upper portion is rather flat, but inferiorly this lamella of bone curves sharply outward. At the inferior ethmoidal fissure this surface turns a sharp angle so as to form the floor of the fissure, and here it faces upward and backward (Figs. 10 and 13). Its length depends upon that of the fissure, and its breadth is commonly that of the lateral mass. It may be separated from the orbital fossa by the inner wall of the latter, or some posterior ethmoid cells may intervene. It may be twelve to thirty millimetres long and ten millimetres wide. This surface directs the pus from these cells into the pharynx. Towards the lower part of the internal surface are grooves for branches of the sphenopalatine artery.

The surface, as a whole, is rather smooth, but occasionally presents well-marked horizontal grooves which are in the centre of the surface, and do not extend into the ethmoidal fissure (Figs. 4 and 7). If very deep, they form a well-marked gutter, and if broad, they tend to reduce the normal convexity of the surface. The anterior extremity occasionally terminates in a pocket, but never in a distinct cell. In only one instance has there appeared a "middle turbinate" which presented a true internal concavity rather than a convexity (Fig. 12). Unlike the external surface, there are no cells on it. It is unusual for a groove to measure more than twenty millimetres long by three millimetres deep and three millimetres wide. They are rarely multiple. The lips of a prominent groove can be observed from the anterior nares and the region explored with a probe.

Occasionally the internal surface may present one or two elevations. The lamella at the agger nasi may be unusually elevated so as to make a prominence called the "tuberculum nasoturbinale," which is simply a well-marked agger nasi. When the superior and inferior ethmoidal turbinates meet at the beginning of the inferior ethmoidal fissure there may be a prominence made by an ethmoid cell; this is called the "tuberculum ethmoidale anticum." The "tuberculum ethmoidale posticum" has been noted in connection with the superior turbinate.

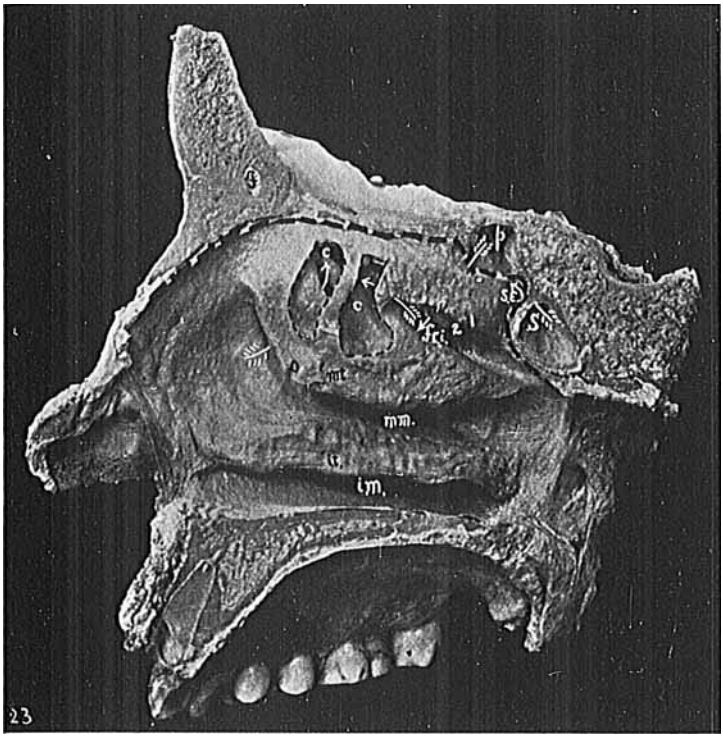


FIG. 5.—Outer wall of right nasal fossa; dotted line marks its roof; double cells in the turbinate. *P*, frontal sinus, membrane just exposed without opening the sinus; *S*, small sphenoidal sinus, with arrow through its ostium; *s.e.*, spheno-ethmoidal recess; *p*, posterior ethmoidal cell, with arrow passing through its ostium into the inferior ethmoidal fissure (*f.e.i.*); 1 and 2, two superior turbinate bones; *m.t.*, middle turbinate with operculum (O). Inferior border, forty-five millimetres; anterior border, twenty-eight millimetres. *c, c*, two cells in middle turbinate with inner wall removed. The anterior one opens into the middle meatus as shown by arrow; the posterior one opens into the ethmoidal fissure above the middle turbinate, and also communicates with the posterior ethmoid cells which extend to the roof of the fossa. The anterior cell is seven millimetres long, seventeen millimetres high, and five millimetres wide; the posterior cell is ten millimetres long, nineteen millimetres high, and six millimetres wide. *i.t.*, inferior turbinate; *i.m.*, inferior meatus.

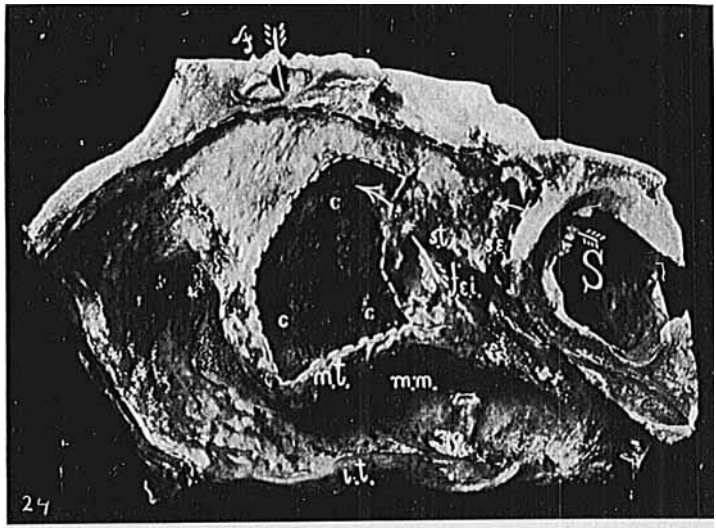


FIG. 6.—Outer wall of right nasal fossa exposing a very large hollow, middle turbinate. The inner wall removed, exposing its cavity (*c, c*), into which an arrow passes through its ostium from the inferior ethmoidal fissure (*f.e.i.*). This cell measures twenty-five millimetres long, thirty-one millimetres high, and fourteen millimetres wide. The height of the turbinate is thirty-five millimetres. *F*, frontal sinus, with arrow passing to middle meatus (*m.m.*); *s.t.*, superior turbinate; *S*, sphenoidal sinus, with arrow passing through its ostium; *s.c.*, spheno-ethmoidal recess; *i.t.*, inferior turbinate.

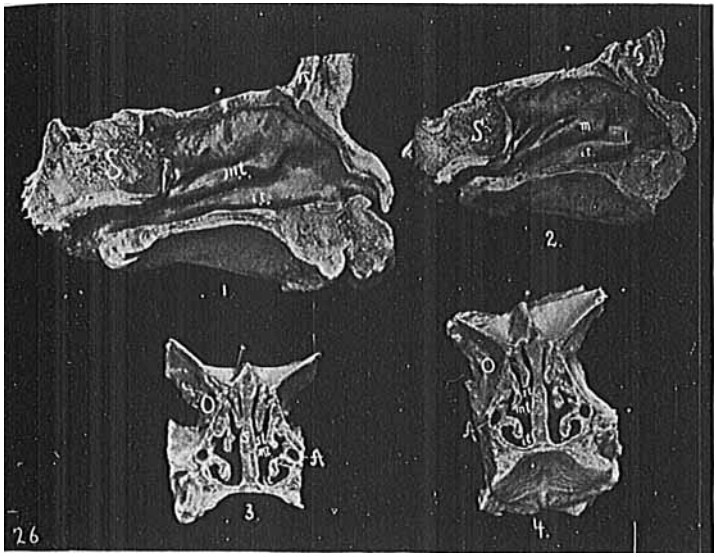


Fig. 7.—Nasal fossa of infant at birth; mucous membrane smooth and comparatively thick.

Nos. 1 and 2, outer wall of left fossa. *F*, cancellated tissue at site of undeveloped frontal sinus: *S*, site of undeveloped sphenoidal sinus; *m.t.*, middle turbinate; *l.t.*, inferior turbinate.

Nos. 3 and 4, transverse sections showing turbinates and meatuses. *O*, orbital fossa; *S*, septum nasi; *s.t.*, superior turbinate; *m.t.*, middle turbinate; *l.t.*, inferior turbinate; *A*, antrum.

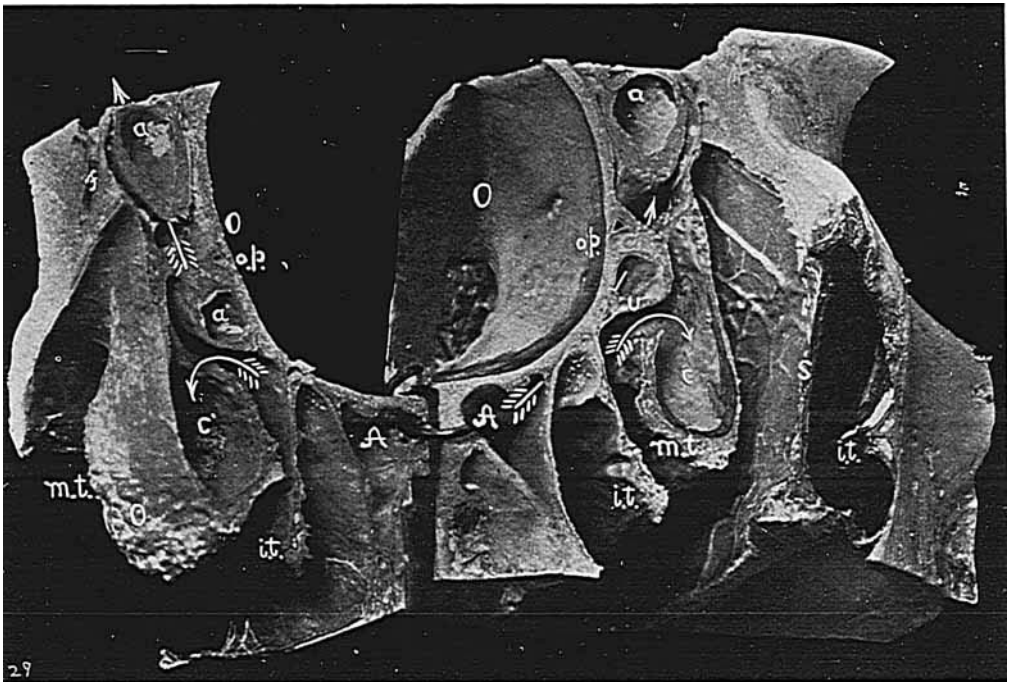


FIG. 8.—Transverse section of right lateral half of a specimen just anterior to the ostium maxillare; the anterior half is rotated outward so as to expose both cut edges, left nasal fossa is intact. *O*, *O*, orbital fossæ; *m.t.*, middle turbinate, anterior and posterior portions; *c*, *c*, corresponding halves of the large cell contained within the turbinate. An arrow marks its ostium into the middle meatus. It is so situated that its holding capacity for fluids with the head erect is considerable; *O*, operculum; *F*, frontal sinus, near which is an arrow entering the sinus just anterior to an anterior ethmoidal cell (*a*) which forms a frontal bulla. The posterior half shows the remaining part of this cell. *o.p.*, os planum of ethmoid bone; *A*, *A*, comparatively small antrum, with an arrow passing out of its ostium directly towards the frontal sinus; *U*, uncinate process, above which is a cell space carried forward and marked *a* in the anterior half and known as the infundibulum. *i.t.*, inferior turbinate; *s*, nasal septum, showing injected arteries.

Internal to the turbinate is the septum nasi, with which it should not be in contact. Usually there is a space of two to five millimetres between them called the olfactory fissure (Figs. 9 and 14). They may be in contact as a result of a malposition of the turbinate or because it contains a large cell, or there may be a deviation of the septum or a cartilaginous or bony spur. It is a clinical observation that the development of the turbinate depends upon the amount of space necessary to fill. For example, if the septum is crowded to one side so as to touch the turbinate, this body is apt to recede, and the two surfaces do not remain in contact. Meanwhile, the concavity on the opposite side of the septum is more or less filled by a compensatory hypertrophy of the opposite turbinate. Most of the increase is due to a hyperæmic condition of the turbinal covering. Opposite the greater part of the inferior ethmoidal turbinate is the lamina perpendicularis of the ethmoid. If the turbinate is large, it may be opposite the triangular cartilage; but the posterior extremity is always opposite the upper part of the vomer. As a result of trauma, the opposing surfaces may become adherent by bands varying in extent, particularly if both surfaces are wounded.

External Surface (Figs. 9, 11, and 14).—The external surface faces outward and presents in general a concavity most marked in the lower horizontal half. This is called the sinus of the turbinate (sinus turbinalis). Towards the superior angle the surface is flat, and near the posterior angle the upper portion of the surface looks downward and forward. This surface is rougher than the internal surface, and commonly presents depressions or pockets and orifices leading to cells which will be considered later.

The external relations of this surface are very important and complicated. Opposite the upper angle is a space which varies in size, and it has been termed the turbinate fossa. In 50 per cent. of all cases the frontal sinus opens here without communicating with the infundibulum (Figs. 9 and 11). Some of the ostia of anterior ethmoid cells are found here. Opposite the turbinate sinus are the bulla ethmoidalis, hiatus

semilunaris, and processus uncinatus. The outline of the bulla frequently corresponds to the concavity of the sinus, but the bulla may be flat, consisting of a simple lamina of bone, may be generally enlarged and symmetrical, or may be drawn out into a nipple-like process (Fig. 14). Hence, its proximity to the turbinate will vary. The general direction of the uncinate process conforms roughly to that of the free borders of the turbinate, but at the extreme upper limit of the anterior border of the turbinate these two structures are usually in contact. The average bulla is about ten millimetres long, and posteriorly its surface is continuous with the under surface of the turbinate. The relation between the bulla and sinus turbinalis is fairly constant, but the former may be so large as to fit into the sinus. Occasionally a band of mucous membrane passes across from one to the other.

The turbinate may be directed outward so sharply as to come in close proximity to the structures external to it, and may occasionally come in direct contact with them. The space may be narrowed, furthermore, by an hypertrophied condition of the mucous membrane or by the presence of polypi. These conditions are of great importance, for the ostia of different sinuses and cells may be obstructed thereby.

Superior Border.—This is the longest border, and it runs obliquely upward and forward across the internal wall of the lateral mass, dividing it into two triangles as mentioned above. It has a bony attachment throughout its extent. Beginning posteriorly at the sphenopalatine foramen, it crosses the superior turbinate crest of the palate bone, thence along the inferior ethmoidal fissure, whence it is continued in the same direction as an imaginary line to the cribriform plate, and then towards the median line to reach the internal surface of the nasal process of the superior maxilla. This is the superior angle. All of the lamina below this line is treated as the inferior ethmoidal turbinate for descriptive purposes. In the disarticulated ethmoid bone, the anterior border is very obvious.

Anterior Border.—This border extends from the superior angle downward to meet the inferior border at the anterior

angle. It is the shortest border. It passes downward for a variable distance on the internal surface of the nasal process of the superior maxilla, often in conjunction with the anterior extremity of the uncinate process. Thence it continues in a general downward direction as a free border, slanting forward or backward to reach the anterior angle. This free angular portion of the turbinate is called the "operculum" (Figs. 1 and 2). The prominence of the operculum depends upon the length of the free portion of this border. It is open to inspection from the anterior nares.

Inferior Border.—The inferior border connects the anterior and posterior angles. It is generally horizontal and is free for its whole extent. It is fairly regular and follows the outward curled portion of the turbinate. This border is thickened, grooved, and channelled for vessels, and towards its anterior end it contains at times dense bone tissue. The border may be deeply notched. The bone tissue is more dense here than elsewhere in the turbinate. A part of this border can be seen from the posterior nares (Fig. 10).

Posterior Angle.—This angle is at the junction of the superior and inferior borders and is situated just below the sphenopalatine foramen, close to the internal plate of the pterygoid process. The bony angle is flat, and, as a rule, it is not accentuated by the mucous membrane, as is the corresponding angle on the inferior turbinate bone. It is on the same level as the Eustachian tube and in the same vertical plane as the angle of the turbinate below. In contrast to the angle of the lower turbinate, a sling can rarely be made to catch on the posterior angle of the inferior ethmoidal turbinate (Fig. 5).

Superior Angle.—This is placed obscurely at the junction of the superior and anterior borders near the roof of the nasal fossa just internal to the ostium frontale. Just external to it is the turbinate fossa, which may be a comparatively wide space and contain the openings of the frontal sinus, the frontal bulla, and some of the anterior ethmoidal cells. Just below it is the prominence of the agger nasi, which corresponds to a turbinate in certain of the lower mammalia.

FIG. 9.—Transverse section just anterior to the ostium maxillare. *F*, frontal sinuses, with arrows passing through their ostia directly into the middle meatus without entering the infundibulum (*i*); *a, a*, anterior ethmoid cells; *A*, antrum. Arrows pass into the infundibulum (*i*) through the ostium maxillare, thence through the hiatus semilunaris into the middle meatus under the middle turbinate bone. *U*, uncinate process, which is placed obliquely and forms the internal wall of the infundibulum; *s*, septum nasi; *m.t.*, middle turbinate. On the left side this turbinate contains a cell (*c*) which communicates with the middle meatus, as shown by an arrow. *i.t.*, inferior turbinate; *o.p.*, os planum.

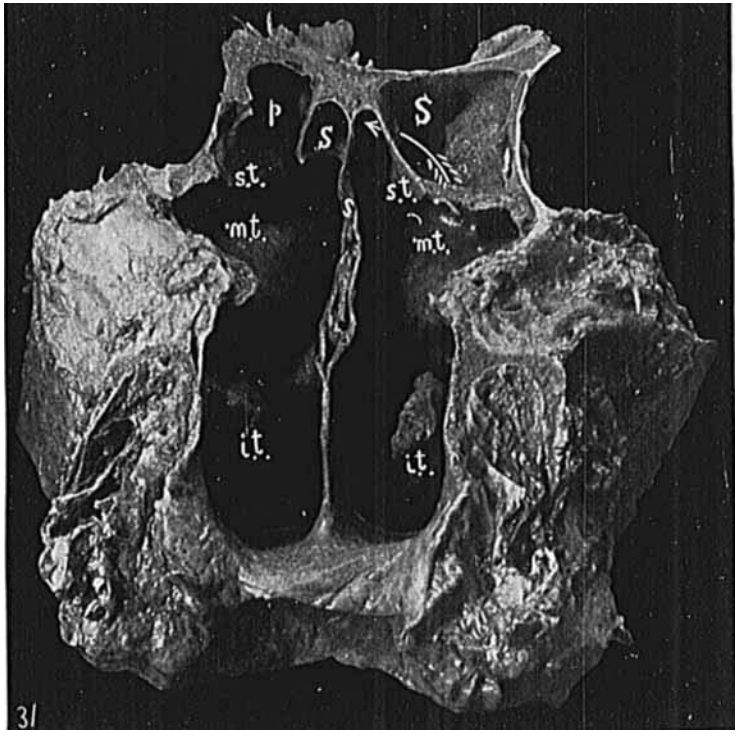


FIG. 10.—Transverse section at the posterior extremity of the middle turbinate bones. The section shows the horizontal aspect of the posterior half of the turbinate (*m.t.*). *S*, right sphenoidal sinus, with arrow passing through its ostium into the nasal fossa. Only a small portion of the left sinus appears, and to the left is a large posterior ethmoidal cell (*p*). *s.t.*, superior turbinate; *s*, septum nasi; *i.t.*, inferior turbinate.

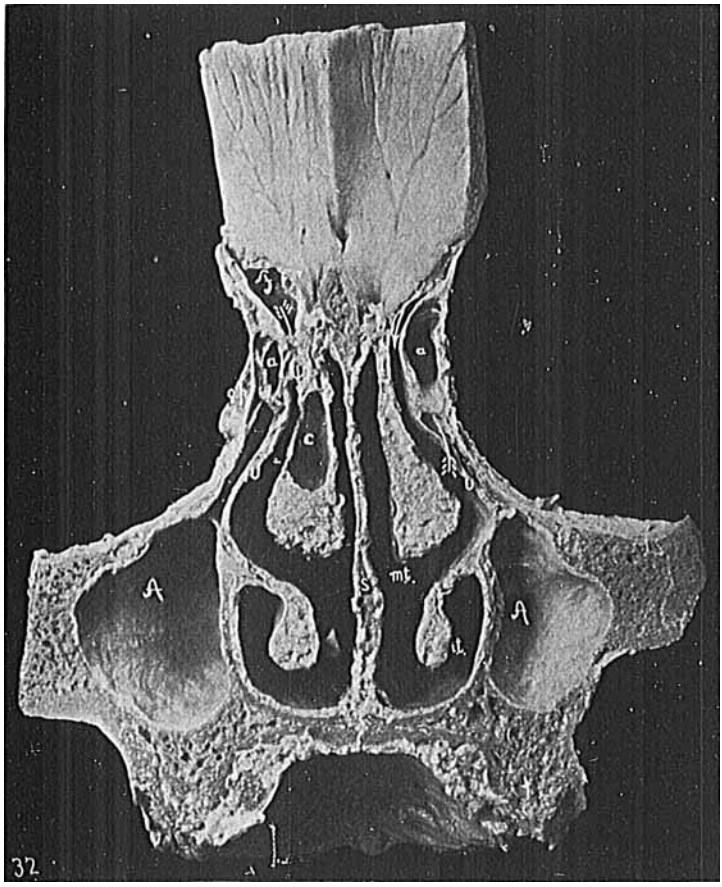


FIG. 11.—Transverse section at the ostium maxillare. *F*, left frontal sinus, with arrow passing through its ostium into the turbinate fossa. A similar arrow emerges from the right sinus. *o.p.*, os planum; *a, a*, anterior ethmoid cells; *m.t.*, middle turbinate bodies, unique in that they consist of very dense bone tissue measuring ten millimetres in width. They contain a cell (*c*) which is larger in the left turbinate, but the cell in the right turbinate is located so far posteriorly as to appear in the posterior half. *U*, uncinate process. On the right side an arrow passes forward in the infundibulum which ends blindly in a cell; *s*, septum nasi; *i.t.*, inferior turbinate; *A*, antrum.

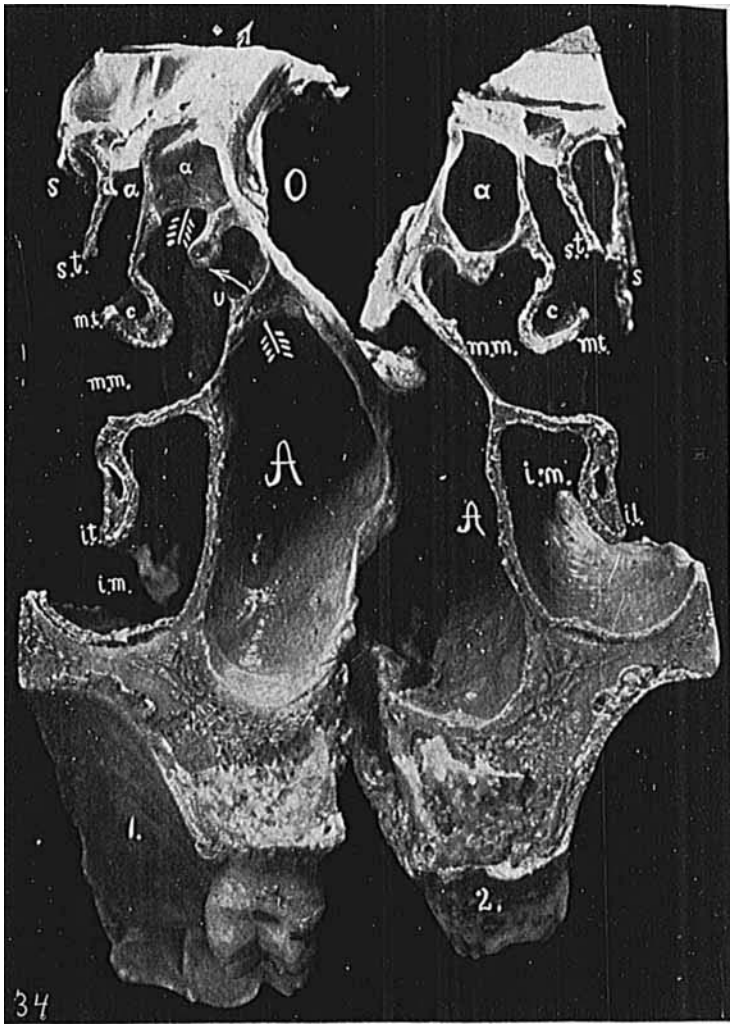


FIG. 12.—Transverse section of right nasal fossa, septum (*s*) fragmentary. The two halves of this specimen are placed side by side. 1, anterior half; 2, posterior half; *s*, septum nasi; *s.t.*, superior turbinate; *a*, anterior ethmoid cells. In 1 an arrow passes forward from the turbinate fossa into the frontal sinus, and a second arrow from the antrum (*A*) into the infundibulum; the antrum is large. *O*, orbital fossa; *m.t.*, middle turbinate in this specimen is unique in that it presents a deep concavity (*c*) on its internal surface; *m.m.*, middle meatus; *i.t.*, inferior turbinate; *i.m.*, inferior meatus.

Anterior Angle.—This angle is at the junction of the anterior and inferior borders. It is the only free angle, and its prominence depends upon the length of these borders; hence, it may be more or less than a right angle (compare lateral views). This portion of the turbinate acts as a sort of cover and is called the "operculum." It is open to inspection from the anterior nares. It may be thick or thin, and is much dilated by an extensive cell formation which has been termed "concha bullosa." The operculum hangs vertically, and may be directed outward or inward.

General Structure and Variations of the Turbinate.—The bony lamella is comparatively thin, particularly at its point of greatest convexity, but along the inferior and anterior borders it is frequently very dense. Throughout the greater part of its extent it is not thicker than an egg-shell, and contains numerous perforations (Fig. 1). The turbinate in the aged are extremely thin and brittle. One specimen (Fig. 11) is unique, and the only example found in which the turbinate is made up of comparatively thick, dense bone.

Variations in the outline have been noted, likewise the occurrence of one specimen which presented a concavity towards the septum (Fig. 12). There is considerable uniformity in size. A relatively large turbinate is shown in Fig. 2.

The turbinate may appear to be absent, as seen in Fig. 3, but in every instance there is either a bony ridge or membranous flap to mark its presence. Ordinarily, when viewed laterally, the bulla and uncinate process cannot be seen, but not infrequently the uncinate process is exposed, and only in cases of extreme atrophy is the inferior border of the turbinate higher than the bulla (Fig. 3). The middle turbinates of opposite sides are never precisely alike, and they often present marked asymmetry (Figs. 9 and 11). The cellular structure will be considered below.

The inferior ethmoidal turbinate is covered with a thin periosteum, a small amount of loose connective tissue, outside of which is mucous membrane possessing ciliated, columnar

epithelium. In the mucous membrane and the connective tissue, especially on the internal surface and lower border, are numerous cavernous spaces which can be filled with blood. The various passages can be thereby much narrowed. The condition is known as hyperæmia, and this tissue is an example of " erectile tissue." Ciliated mucous membrane lines the structures which have been considered above, including all the cells connected with the ethmoid bone.

The blood supply of the middle turbinate is derived chiefly from branches of the sphenopalatine artery, and these run forward along the inferior portion, forming an extensive anastomosis.

The sensory nerve supply is derived chiefly from branches of the superior maxillary division of the fifth pair of cranial nerves. A few branches of the olfactory nerve are distributed in the vicinity of the superior angle, extending down a short distance on the internal surface of the turbinate.

Cells of the Inferior Ethmoidal Turbinate (Figs. 4, 5, 6, 8-14, 15, 16).—Ordinarily, the middle turbinate consists of a thin, curved lamella of bone which is a part of the ethmoid bone. It is thinnest opposite the sinus turbinalis, and its thickest portion is along the inferior and anterior borders in the vicinity of the inferior angle. This thickened portion may be more or less cancellated and tunnelled for vessels, and is sometimes of sufficient width as to present an inferior surface. Small exostoses sometimes occur.

As will be seen below, it is a common occurrence for this lamella of bone to contain cells of different sizes and shapes, located in different portions of the turbinate. A cell located in any portion of the turbinate can be properly called a middle turbinate cell, and all such cells will be considered below. These are strictly ethmoid cells and could be classed as anterior or posterior, as will be observed below.

There is much confusion in the literature as to the origin and nature of these cells, which I believe is due primarily to a lack of investigation of a large number of normal turbinates, and, secondarily, to errors by clinicians who remove portions

of cell walls which have been changed by pathological processes, and are led to believe that all such cavities are pathological. They are usually described as "osseous cysts." In anatomical works the first mention of cells of the middle turbinate was made by Santorini, and later similar observations were made by Zuckerkandl. So far as I can learn, no other very extended anatomical investigation has been made. Dupuytren appears to have made the first clinical report of middle turbinate cells.

As has been noted, the following statements and conclusions are based on the study of about one thousand middle turbinate bones, obtained from dissecting-room subjects and museum specimens. The turbinates of very few children could be obtained, but a considerable number of new-born infants were examined. By far the greater number of specimens represent the adult condition, including all ages. The sex in these cases was not followed closely, and there seemed to be no reason for believing that cells appeared more commonly in one sex than the other.

Age.—There are no ethmoid or middle turbinate cells at birth. The ethmoid cells begin to develop at about five years of age, but I discovered no turbinate cell in children. They were equally common in all ages of adults. Comparing the cells of all ages, they appeared to reach their normal development synchronously with the ethmoid cells, and then remained stationary unless altered by disease or the thinning of bone in old age.

Occurrence.—Of 1000 inferior ethmoidal turbinates, eighty-nine contained a cell, making about 9 per cent. of all cases. In a previous smaller series of cases, all of which are included in the above, the percentage was eighteen, hence it was a matter of chance that the early specimens contained cells. In 6.7 per cent. only a single cell was present, in 1.3 per cent. two or rarely more cells coexisted. In ten of the 1000 cases, or 1 per cent., both middle turbinates of the same subject contained cells. The cells were slightly more frequent in the right than in the left turbinate.

No cell was discovered in the inferior turbinate. In the superior turbinate region, the lamella of bone which constitutes this turbinate is often very thin and narrow, so that the turbinate is practically a strip of bone crossing a posterior ethmoid cell. The prominence of the superior turbinate often depends upon the size of a posterior ethmoid cell.

Location of Cells in the Turbinate.—Almost without exception the cell is situated somewhere in the anterior half of the turbinate. If it occupies any part of the posterior half, it is always one of the bullous type of large cells which occupies the anterior half as well (Figs. 6, 14, 15, 16). More commonly a single cell is located near the central part of the turbinate in the vicinity of the anterior extremity of the inferior ethmoidal fissure (Figs. 4, 5). When the cell is very large, the condition has been called "concha bullosa." Only in this type does the cell extend for any degree to the inferior border or to the inferior angle. In most cases there remains a strip of cancellated bone along the anterior and inferior borders (Fig. 9.)

Occasionally the cell may extend towards the superior angle, forming part of a large anterior ethmoid cell, thus reaching the roof of the nasal fossa. The frontal sinus may communicate thus with a cell in the turbinate. More often the turbinate cell communicates with a large posterior ethmoidal cell so as to reach the level of the lamina cribrosa (Figs. 6, 15, No. 6, and 16, Nos. 5 and 6). As a rule, the turbinate cell occupies a position between the anterior angle and anterior end of the inferior ethmoid fissure encroaching upon the area of the turbinate sinus from in front and above (Fig. 14).

Types of Cells.—Cells of the turbinate may be classified according to their size, small or large, or according to whether they open into the middle meatus or the inferior ethmoid fissure. The size of cell bears no relation to the situation of its ostium.

Small cells are common near the anterior extremity of the ethmoidal fissure, extending a variable distance into the turbinate; these open into the fissure, and they can be recog-

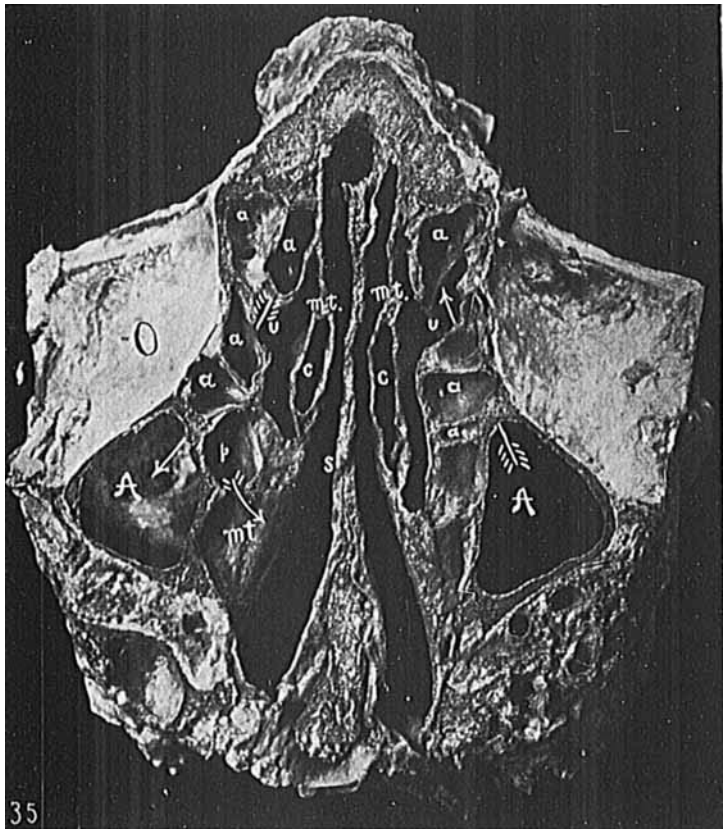


FIG. 13.—Horizontal section above the level of the ostium maxillare. *A*, antrum, with arrows indicating the position of the ostium maxillare and lying in the infundibulum; *U*, uncinate process; the cavity just external to the letter is the infundibulum; *a, a*, anterior ethmoid cells; *p*, posterior ethmoid cells; *s*, septum nasi; *O*, orbital fossa; *m.t.*, middle turbinates. The posterior half of each turbinate is horizontal; the anterior half is vertical, and in each instance the turbinate contains a cell (*c*). The dark space external to these turbinates is the middle meatus, and the long, dark area internal to the turbinates divided by the septum is the general cavity of the nasal fossa.

FIG. 14.—Lateral view of middle turbinates still covered with mucous membrane. A dotted line along the upper border shows the line of attachment to the lateral mass of the ethmoid bone. The cavity of cells (*c*) has been exposed by removing a portion of the lateral wall. *s*, sinus turbinalis. Portions of the superior turbinate appear in Nos. 4, 7, 10, and 13.

1. External wall of right turbinate; arrow passes into a cell through its ostium from the middle meatus.

2. Internal surface of left turbinate marked by a deep groove (*g*).

3. External surface of right turbinate; arrow passes through a large ostium into a cell which occupies the anterior half of the turbinate.

4. External wall of left turbinate. *a* and *p* represent the broken ethmoid cells; *B*, ethmoid bulla, with arrow entering the cavity through its ostium.

5. External wall of right turbinate showing a cell which occupies the anterior half of the turbinate opening into the middle meatus.

6. External wall of right turbinate which contains a cell occupying the anterior third of the turbinate.

7. External wall of left turbinate, the middle third of which contains a cell.

8. External wall of right turbinate containing a cell which occupies the greater part of the turbinate. It opens into the middle meatus. It measures twenty-nine millimetres long, nineteen millimetres high, and ten millimetres wide.

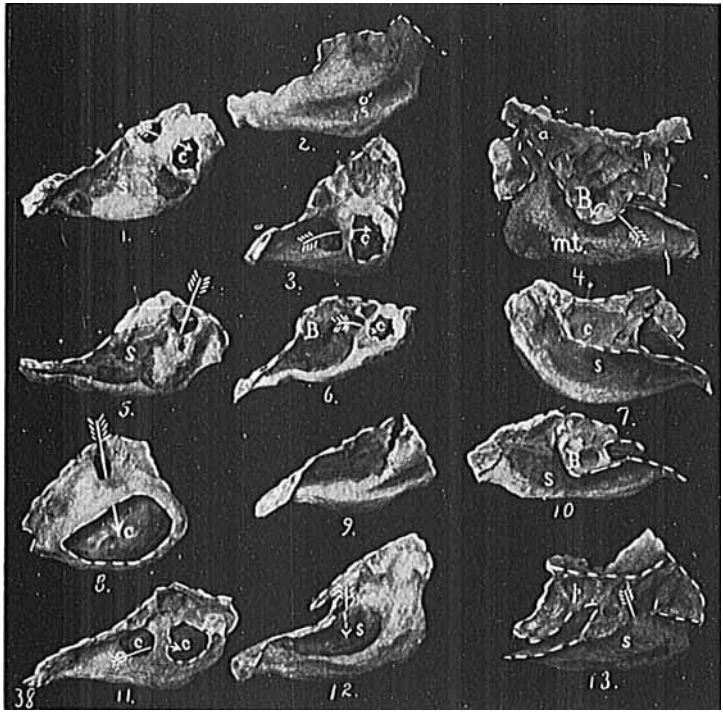
9. Internal wall of left turbinate.

10. External wall of left turbinate. *B*, bulla.

11. External wall of right turbinate containing a cell in anterior third. The *c* to the left is at the ostium of the cell.

12. External wall of right turbinate. The arrow shows a cell placed vertically in the middle third of the turbinate. The turbinate sinus is deep.

13. External wall of right turbinate; arrow enters a large cell in anterior half of turbinate.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nized by a small oval prominence on the internal surface of the turbinate (Figs. 5, 15, 16). The cavity within the fissure seems to be carried down into the cell.

The cells possessing these characteristics resemble closely in every way anterior and posterior ethmoidal cells.

Another variety of small cells is associated with the sinus turbinalis, and these cells are often multiple. It would seem as though small pockets opening into the sinus became deeper and the ostium smaller until a well recognized cell was formed. They are essentially diverticula from the sinus. The mucous membrane makes these cells more pronounced. These smaller cells opening into the sinus are common and have very little clinical importance. They are near the inferior portions of the turbinate, and do not communicate with the anterior ethmoid cells. Examples are seen in Fig. 14, Nos. 3, 5, 6, 11.

The larger cells observed in the inferior ethmoidal turbinate are of fairly common occurrence, and it is to this type that the name "concha bullosa" has been applied. About 5 per cent. of all middle turbinates possess such a cell. It is this condition which is of peculiar surgical importance, and this variety includes most of the clinical cases reported. There is no relation between the size and location of these cells and the location of the ostium.

As a rule, the cell occupies the anterior half of the turbinate, whence it may extend upward or backward according to its size. The turbinate is wide, thus increasing the normal convexity towards the septum nasi, and at the same time encroaching upon the turbinate sinus. The larger cells extend fully to the anterior angle, but sometimes a strip of cancellated bone remains along the inferior and anterior borders (Fig. 9). Frequently these cells extend well towards the posterior angle, and superiorly they may communicate by a large passage with posterior or anterior ethmoid cells, so as to form a large chamber extending to the level of the lamina cribrosa. In many instances these turbinate cells are obviously a part of an ethmoid cell which is situated partly in the lateral mass and the turbinate. Ethmoid cells and frontal sinus may drain

into a middle turbinate cell (Figs. 15, No. 3, and 16, Nos. 4, 6). The cells are oval and flattened laterally.

The size of the cells varies. The following table shows the size and relative variations of the three dimensions of some of the larger cells:

Height.	Length.	Width.
Millimetres.	Millimetres.	Millimetres.
18	11	12
17	20	7
20	15	8
14	18	11
20	25	8
8	10	5
31	25	14 (Fig. 6)
25	15	12 (Fig. 4)
19	29	10 (Fig. 14, No. 8)

Ostia.—Every ethmoid cell without exception possesses an ostium. An occasional clinical case has been reported where it is claimed that the cell possessed no ostium, and the reason for such conclusion is readily understood when the location of the ostium is considered.

Location.—Whenever the cell opens above the middle turbinate bone into what is usually called the superior meatus of the nose, the location of the ostium is constant, irrespective of the size of the cell. It is situated at the extreme anterior end of the inferior ethmoidal turbinate, more or less concealed, when viewed laterally, by the lamina of the superior turbinate (Fig. 6). It is oval and from two to four millimetres in diameter. The ostium of a large cell does not differ much in any respect from that of a small cell. In all instances it is placed at about the highest level of the cavity, and therefore it is most unfavorably placed to facilitate drainage from any cell within the turbinate. All turbinate cells which communicate directly with posterior ethmoid cells open thus. Of all turbinate cells about 45 per cent. open into the inferior ethmoidal fissure, *i.e.*, the region commonly termed the superior meatus.

Middle turbinate cells may open below the turbinate into the middle meatus, and of all cases about 55 per cent. com-

municate thus with the nasal fossa. A few of the smaller cells may open into any portion of the turbinate sinus, but these are usually small diverticula from the sinus and of comparatively slight importance. The ostium of the larger cells occupies a very constant position on the external surface just above the turbinate sinus. It is opposite a point above and anterior to the upper portion of the ethmoid bulla (Figs. 4, 8,.9). In shape it is commonly crescentic with the convexity downward, and may measure from three to ten millimetres in length. Its plane is parallel to that of the turbinate, but the plane of the ostium opening above the turbinate is at right angle to that of the turbinate. This type of ostium is at the upper portion of the cell and offers poor drainage. A somewhat larger percentage of the bullous type of cell opens into the middle meatus. It is the cells opening by this route that communicate with the anterior ethmoid cells, the frontal sinus, and frontal bulla.

If a bullous turbinate is removed by snare or forceps, the line of fracture is below or through the ostium, hence the removed portion may contain a large cell without any apparent ostium.

The disposition of ostia varies when multiple cells are present in the same turbinate. Both cells never open above but both may open below (Fig. 16, No. 1) the turbinate, or there may be an ostium on either side (Figs. 5 and 15, No. 5). When the cells are arranged one in front of the other, the anterior cell generally opens into the middle meatus, the posterior into the superior meatus (Fig. 5). Of thirteen turbinates containing comparatively large double cells, in no instance did both cells open above the turbinate, but in three cases both communicated with the middle meatus, and in ten cases one cell opened above and the other below the turbinate. Occasionally the turbinates of opposite sides contain a cell, both communicating with the nasal fossa by the same or different routes.

The walls of the cells varv in thickness within narrow limits. The lateral walls are usually thinner than the wall of

an ordinary turbinate, and if the cell is of the bullous type and extends fully to the anterior border, the front wall is equally thin. Where the cell is small and occupies the upper portion of the turbinate, the proper lateral walls of the cell are thin, but the remaining portion of the lamella of the turbinate is unchanged. Partitions between cells are thin.

The mucous membrane which lines these cells does not differ from that lining the general cavity in the ethmoid region. It is devoid, however, of the erectile tissue which is characteristic of the internal surface of the turbinate. It consists of ciliated columnar epithelium and basement membrane, together with some loose connective tissue in which are distributed lymph and blood-vessels and glands. The osseous tissue is characteristic of that belonging to the ethmoid bone. As a result of pathological processes, such as catarrhal inflammation, hypertrophy, polyps, and atrophy, the appearance of the mucous membrane may be profoundly altered.

Relation of Cells to Surrounding Structures.—Internal to the cells is the septum nasi (Figs. 9 and 13), and, according to the size of the cell and the angle of the turbinate and the curvature of the septum, the cell wall may be in contact with the septum. Adhesions are rare.

External to the cell we have the bulla and uncinate process, together with the important ostia in the vicinity. A cell of any considerable width is apt to obstruct these ostia, giving rise to symptoms according to the ostium involved. There is no structure immediately in front of the cell, but posteriorly there is often a portion of the bulla, if prominent, and the accentuated concavity of the turbinate sinus (Fig. 14).

Recognition of the Presence of Middle Turbinate Cells.—The vicinity of the anterior angle of the middle turbinate is practically always in view when examined from the anterior nares. An unusual width of this region may be due to a deviation or undue curling of the turbinate or to the presence of a cell. The bullous type can be seen filling up the apertura pyriformis, and perhaps obstructing the olfactory fissure, or even extending from the septum to the bulla. Only in exceptional

FIG. 15.—Internal surface of a series of turbinate bones which contains a cell (c). The internal wall of the cell has been partly removed, as shown by a dotted line. The horizontal line marks the roof of fossa. *c.g.*, crista galli; *s.t.*, superior turbinate; *m.t.*, middle turbinate; *f.e.t.*, inferior ethmoidal fissure; *S*, sphenoidal sinus with arrow through its ostium.

1. *c*, cell, into which an arrow passes through a wide ostium from the middle meatus; *U*, uncinate process; *B*, bulla ethmoidalis; arrow passes between bulla and uncinate process to antrum. A long arrow passes from the frontal sinus to the middle meatus.

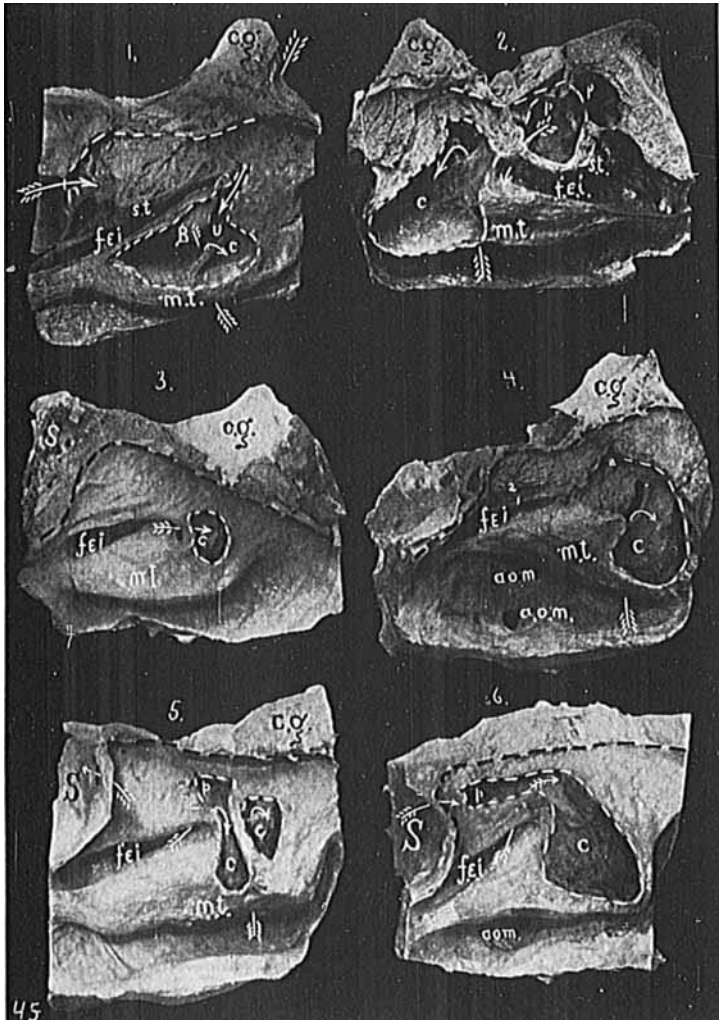
2. A large bullous cell, with arrow from middle meatus occupying the anterior half of turbinate. It measures twenty-three millimetres long, twenty-six millimetres high, and twelve millimetres wide. A posterior ethmoid cell (*p*) opens into the ethmoid fissure as indicated by arrow.

3. Small cell opening into the ethmoid fissure.

4. A large cell in the anterior third of turbinate, which communicates with middle meatus by a long semilunar ostium (arrow) and extends above it into an anterior ethmoid cell. *a.o.m.*, accessory ostium maxillare; 1 and 2, two superior turbinates. Turbinate cell measures fifteen millimetres long, twenty millimetres high, and nine millimetres wide.

5. A turbinate containing two distinct cells; the anterior one communicates with the middle meatus, the posterior with the ethmoid fissure, as shown by arrows.

6. A very large cell which is continuous with posterior ethmoid cell and opens into ethmoid fissure. *a.o.m.*, accessory ostium maxillare. It measures twenty-two millimetres long, thirty millimetres high, and nine millimetres wide.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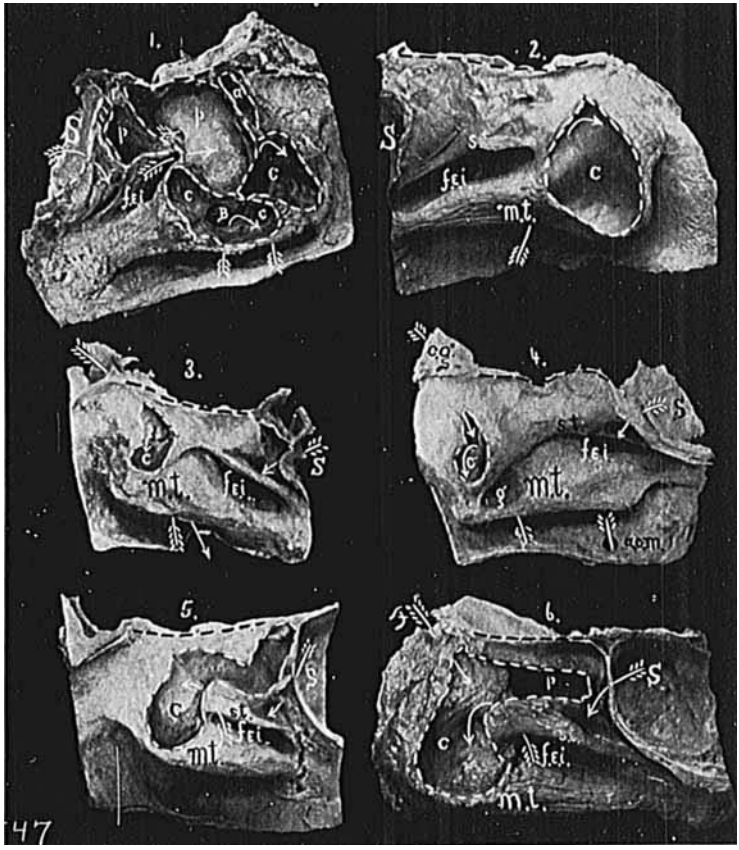

FIG. 16.—Internal surface of a series of turbinates which contain a cell (c), the wall of which has been removed and marked with a dotted line. Horizontal line corresponds to roof of nasal fossa. *S*, sphenoidal sinus, with arrow indicating ostium; *s.t.*, superior turbinate; *m.t.*, middle turbinate; *f.e.i.*, fissura ethmoidalis inferior; *a*, and *p*, anterior and posterior ethmoid cells.

1. Section passes through two cells in the turbinate and also some ethmoid cells; both turbinate cells open into the middle meatus.

2. Large cell measuring eighteen millimetres long, twenty-one millimetres high, and ten millimetres wide.

3. Small cell in upper portion of turbinate.

4. Small cell opening into middle meatus; posteriorly is a short, deep groove. An arrow passes from frontal sinus to the turbinate fossa; an arrow enters the antrum through the accessory ostium.

5. A large cell continuous with a posterior cell, both of which open into the ethmoid fissure by a common ostium. It measures twenty-two millimetres long, thirty-two millimetres high, and ten millimetres wide.

6. A large cell similar to 5, measuring thirty-three millimetres long, twenty-one millimetres high, and eleven millimetres wide.

instances could the presence of a cell be detected by posterior rhinoscopy (Fig. 10). The location of the ostium could not be determined in a normal cell.

Origin of Cells in the Inferior Ethmoidal Turbinate.—Embryology shows that at birth there are no cells associated with the ethmoid bone (Fig. 7); that at four to five years cells begin to develop by the pushing in of pockets lined with mucous membrane; that at puberty the ethmoid cells are fully developed; that the cells do not change materially in health, but that in the aged they may become a little larger in consequence of atrophy of their walls. The inferior ethmoidal turbinate or "middle turbinate" is a portion of the ethmoid bone, and its development depends upon that of the rest of the bone.

Anatomical research of a large number of normal middle turbinates reveals the following facts: That in about 9 per cent. of all turbinates examined bony cells were present; that these cells frequently communicated with either anterior or posterior ethmoid cells, and were occasionally multiple; that the cell could lie partly in the lateral mass and partly in the turbinate; that the structure and appearance of the cells resemble those of ethmoid cells; that the cells very rarely showed the presence of any pathological process; that all these cells have ostia; that frequently the superior turbinate consisted of a narrow lamella or a sharp ridge on a posterior ethmoid cell. No closed bone cavities or bone cysts were discovered in any of the turbinate bones.

There are two theories among clinicians as to the formation of cavities or cells in the inferior ethmoidal turbinate:

(1) That these are closed osseous cystic cavities produced by an inflammatory process giving rise to an exaggerated curling of the bony lamella until it has formed a bony cavity or osseous cyst. In these instances there is claimed to be an absence of lining mucous membrane and a particular arrangement of osteoclasts and osteoblasts.

(2) That these cells already exist in the turbinate as normal structures, and may be the site of subsequent inflammation with consequent pathological changes.

The following conclusions are drawn as regards the occurrence of these turbinate cells, based chiefly on anatomical investigation:

That the presence of turbinate cells in 9 per cent. of all cases is not a pathological condition; that these cells are normal in every respect; that they are usually not large, but that even the largest cells do not differ from the anterior and posterior ethmoid cells, and develop in the same way and are really ethmoid cells; that the presence of most of the cells could not give rise to any symptoms, but that even without any pathological changes the cell may become large enough to cause obstruction to respiration, to interfere with the sense of smell, and to give rise to reflex symptoms in consequence of pressure; that as a result of inflammation secondary changes may take place in the mucous lining and also in the bony wall of the cell, whereby its general character and size may be altered, particularly when the ostium becomes closed; that cells of considerable size must exist without their presence being known until the patient seeks relief for nasal obstruction, when a cell may be discovered complicating an acute catarrhal process which was just enough to make complete an already partial obstruction; that in cases of empyema of such a cell where the ostium remains closed, we have practically an abscess cavity, the walls of which are capable of great distention.

THE CLINICAL HISTORY OF MIDDLE TURBINATE CELLS.

The salient clinical features of these cases will be reviewed briefly, based upon the reported cases and a recent well-marked example occurring in the practice of the writer.

Occurrence.—There are about thirty authentic cases on record. All cases occurred practically in adults, the youngest patient being sixteen years old. Although about three-fourths occurred in females, there is no reason why one sex should be prone to the condition. More than half the cells contained air and the walls were not the seat of any pathological process. There were five well-marked examples of empyema of the cell,

while other cases were complicated by the presence of hypertrophied tissue and polypi within the cavity. They were about equally distributed on either side, and in two instances both middle turbinates were involved.

Symptoms.—In all probability most turbinate cells give rise to no symptoms. They are subject to the same changes undergone by other ethmoid cells in health and disease.

There are two general groups of symptoms which may be caused by middle turbinate cells,—one due to the size of the cell, the other due to the presence of inflammation. Both factors may be present simultaneously. The cell may be of sufficient *size* to cause the following symptoms:

There may be complete or partial obstruction to respiration, generally unilateral, which persists irrespective of the presence or absence of a rhinitis. This gives a sense of pressure. Mouth breathing may be necessary.

Pain is often referred to one side of the face and is of a neuralgic character. This may be distributed along any of the branches of the trifacial nerve, manifested as pain along the supra-orbital nerve, about the eye, or in the teeth of the superior maxilla.

There may be a nasal quality to the voice.

The sense of smell may be interfered with.

There may be headache and occasionally dyspnœa on exertion.

Reflex nervous symptoms have been reported as due to the pressure of the turbinate on neighboring structures.

No authentic reports of external nasal deformity due simply to an enlarged turbinate cell are on record. Such enlargement may cause a deviation of the septum and distort the structures external to the cell, causing secondary symptoms in the antrum and frontal sinus. Photophobia, epiphora, and exophthalmos are said to accompany the condition.

In general, it may be said that a non-inflamed turbinate cell causes no symptoms, but that otherwise the chief complaint is that of unilateral nasal obstruction with a sense of fulness and some pain in the nose.

Whenever such a cell becomes inflamed the character of the symptoms changes. Until the onset of these symptoms there may have never been any trouble caused by the cell. The symptoms due to inflammation may supervene on those already existing in consequence of pressure. The symptoms of acute rhinitis with obstinate nasal obstruction commonly cause the patient to seek medical advice, when the true condition may be observed for the first time. The obstruction may remain obstinate, and if the ostium is occluded, an empyema of the cell follows because the retained contents of the cell become infected. The usual changes due to suppuration in mucous membranes follow, until eventually the cell ruptures with or without bony rarefaction and cell enlargement. The persistence of hypertrophy and polypoid degeneration favor the obstruction and suppurative process, and the nasal discharge persists. Crusts collect and there may be odor. A suppurative process well established in such a cell is apt to become chronic because of the unfavorable location of the ostium for drainage.

Diagnosis.—It is usually difficult to diagnose the presence of a small middle turbinate cell which is not the source of any discomfort. If the cell is in the upper portion of the turbinate, its presence cannot be established. Only the bullous type of cell can be determined with any degree of satisfaction. Through the anterior nares, a tumor presents in the apertura pyriformis, with rounded outline and occupying the position of the inferior ethmoidal turbinate ("middle turbinate"). A small probe can be made to pass between it and the nasal septum and externally between the tumor and the outer nasal wall. It is immovable and hard, although its covering mucous membrane may be hypertrophied. The wall may be thin and bend under the pressure of the probe. The diagnosis is confirmed if a probe or other instrument breaks through the wall and enters a cell cavity. Pus may be made to escape from an opening made in the cell in cases of empyema. In a case of empyema of the bullous type of cell, operated recently by the writer, the cell wall was thin and very membranous. In this instance, pressure on the cell with a probe caused an excess

of pus to escape from well above the turbinate, showing that the ostium was situated at the inferior ethmoidal fissure. The diagnosis of the presence of multiple cells would be very difficult.

A differential diagnosis should include the following conditions, which will be simply enumerated: Polypi. Hypertrophy of mucous membrane. An abnormally prominent ethmoid bulla or other ethmoid cell. Cysts of the mucous membrane of the turbinate. Abnormally broad curvature of the turbinate. Malignant tumor. Osteoma of turbinate. Cell of turbinate.

Treatment.—The treatment of any condition due to the presence of a cell in the inferior ethmoidal turbinate presents no difficulties and offers the hope of permanent relief. The part can be thoroughly anæsthetized by means of cocaine, and the hæmorrhage carefully controlled during operation by means of a solution of adrenalin chloride.

The cell may be removed by means of the snare or any cutting instrument. It is probably wise to remove all of the cell. This can be done at one time with the snare, provided the cell is small; but if the cell is very large, a portion of it usually remains behind. This may be removed subsequently with cutting forceps, or, if it does not press on the structures laterally, it may be left after the interior has been carefully curetted.